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Soil Crystallinity As a Climate Indicator: Field Experiments on Earth and Mars.

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Soil crystallinity is largely determined by leaching rates, as high leaching rates favor the rapid precipitation of short order or poorly-crystalline phases like the aluminosilicate allophane. High leaching rates can occur due to high precipitation rates, seasonal monsoons, or weathering of glass, but are also caused by the rapid onset of seasonal melting of snow and ice in cold environments. Thus, cold climate soils are commonly dominated by poorly crystalline phases, which mature into kaolin minerals over time. Thus, we hypothesize that, in some contexts, soils with high abundances of poorly crystalline phases could indicate formation under cold climatic conditions.

This model could be helpful in interpreting the poorly-constrained paleoclimate of ancient Mars, as the crystallinity of ancient soils and soil-derived sediments appears to be highly variable in time and space. While strong signatures of crystalline phyllosilicates have been identified in possible ancient paleosols on Mars, Mars Science Laboratory rover investigations of diverse ancient sediments at Gale Crater has shown that they can contain very high abundances (40-50 wt%) of poorly crystalline phases. We hypothesize that these poorly crystalline phases could be the result of weathering by ice/snow melt, perhaps providing support for sustained cold climates on early Mars punctuated by more limited warm climates. Furthermore, such poorly crystalline soils could be highly fertile growth media for future human exploration and colonization on Mars.

To test this hypothesis, we are currently using rover-like instrumentation to investigate the mineralogy and chemistry of weathering products generated by snow and ice melt in a Mars analog alpine environment: the glaciated Three Sisters volcanic complex in central Oregon. Alteration in this glacial environment generates high abundances of poorly crystalline phases, many of which have compositions distinct from those identified in previous terrestrial investigations, and perhaps more similar to poorly crystalline phases identified on Mars.

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